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# BRIEFING BY CREW OF THE SPACE SHUTTLE MISSION 51-D

## HEARING

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

NINETY-NINTH CONGRESS

FIRST SESSION

ON

BRIEFING BY THE ASTRONAUTS OF SHUTTLE MISSION 51-D

JUNE 6, 1985

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THURSDAY, JUNE 6, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
*Washington, D.C*

The Subcommittee met, pursuant to notice, at 10:10 a.m., in room SR-253, Russell Senate Office Building, Hon. Slade Gorton (Chairman of the Subcommittee) presiding.

Staff members assigned to this hearing: Pete Perkins, professional staff member and Marty Kress, minority staff counsel.

## OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. I am pleased to welcome the crew of Shuttle Mission 51-D to this hearing of the Subcommittee on Science, Technology, and Space. We will discuss the activities and results of mission 51-D and their likely effect on future Shuttle missions. I would also like to extend a special welcome to my colleague and good friend, Senator Garn, a payload specialist on this mission. We congratulate you on a job well done, Senator Garn, and hope to benefit from the vaulable insight you gained on this mission.

As eventful and newsworthy as your *planned* mission was, surely none of you could have anticipated the dramatic turn of events caused by the failure of Leasat to achieve its proper orbit. Your daring attempt to activate Leasat in an emergency rendezvous has now set the stage for a potential rescue attempt of Leasat on a later Shuttle mission—a salvage effort that undoubtably will be filled with risk, yet with an even greater reward, should the rescue attempt prove successful.

But let us not divert our attention from your own undertaking. Even though your attempts to activate Leasat were thwarted, your innovative and resourceful effort was overwhelmingly successful in laying the foundation for a subsequent rescue attempt. Also, it should not go unnoticed that your own attempt to activate Leasat was complicated by the risk of approaching a spacecraft filled with a highly volatile propellant. If NASA pays additional compensation for "hazard duty" you have justly earned this bonus!

Your attempted rescue demonstrated once again NASA's creativity and versatility in performing unprecedented maneuvers in space. That you were called on to rescue Leasat without a rehearsal is a testimony to the confidence that your colleagues have in each of you. And this confidence in your abilities is not restricted to your colleagues. Had the decision to make this unrehearsed attempt been left with anyone in this room, I am sure the overwhelming response would have been to "go for it." Once Leasat is safely activated and operating, each of you will have every right to share in the success of this triumph of will and ingenuity.

Not to be overlookled in this mission was the continued progress in the electrophoresis drug manufacturing operation. Your endeavors in this exciting new activity have served as the pathfinder for space commercialization and for other commercial space activities likely to follow, such as the processing of metals, alloys, and crystals.

Your presence here today underscores the continued preeminence of NASA and the Shuttle program and is a source of inspiration to us all. You "extended the envelope" on this mission, and for this we owe you a debt of gratitude. Thank you for joining us today. We look forward to your discussion of the mission.

At this time, I want to express our great admiration for your resourcefulness, for the way in which you dealt with unexpected challenges in the mission, and, in fact, by the efforts of Senator Hollings and myself, we have secured a resolution passed by the Senate thanking you for the safe return of our colleague, Senator Garn, by a vote of 51 to 47.

Senator GARN. I did not expect such a big margin.

Senator GORTON. But we do feel that all of you, including the colleague of whom we are immensely proud, are a part of the magnificent tradition of NASA as individuals, as technicians, as scientists, that you have kept the tradition of adding to the store of knowledge of people the world over and to the technology of the United States.

We are really very, very pleased to have you here.

Fritz?

## OPENING STATEMENT BY SENATOR HOLLINGS

Senator HOLLINGS. Thank you, Mr. Chairman. Each shuttle crew that comes up comes with even greater feats. This one, to have put up with barfing Jake for 7 days, has really accomplished a feat.

We thought we had seen it all last year when the Ace Repair Company repaired the Solar Max Satellite. However, as soon as the dust had settled, the Mighty Joe Allen and Dale Gardner Towing Service rescued two errant satellites. Through the efforts of the NASA shuttle astronauts, the meaning of the Three-Rs in the space age was being redefined to Repair, Refueling, and Retrieval.

Now, the Shuttle Mission 51-D flight has introduced a fourth R—Reactivate! But this was no sinmple push the restart button reactivation. This was high drama in space as Rhea Sheddon tried to position a homemade fly swatter to catch the timer on the Leasat satellite. And we all sat and watched and hoped with the same level of anxiety and excitement as the astronauts. The effort failed, but the value of man in the loop was proven once again.

Mr. Chairman, despite NASA's valiant effort, flight 51-D will probably be remembered as the mission that failed to deploy the Leasat satellite. That's unfortunate because flilght 51-D should be remembered for what it did accomplish.

First, flight 51-D marked the first time an extra vehicular activity contingency plan was utilized.

Second, the Canadian Telesat satellite was successfully deployed.

Third, additional electrophoresis experiments were conducted that bring the McDonnell Douglas/Johnson & Johnson team one step closer to the development of new pharamaceuticals.

Fourth, a series of successful zero-g and medical experiments were conducted.

And, fifth, but not least, our friend and colleague, Senator "B.J."—"Barfing Jake"—Garn made his historic trip on the shuttle.

Guess there's still truth to the old line, "fairy tales can come true, it can happen to you, if you're young at heart."

I extend a heartfelt welcome to the crew of Shuttle Mission 51-D, and I look forward to the account of your mission.

We are proud of Senator Garn and proud of each of you. The dedication and discipline that is entailed in the years and years of training you undergo and what you are doing for our country is what is keeping our space program alive. Thank you.

Senator Riegle has asked to have his opening statement placed in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR RIEGLE

Mr. Chairman, today's hearing promises to break new ground in the history of this subcommittee. We will receive a report on flight 51-D of the Space Shuttle, which in and of itself is not a departure from the norm, but given the fact that one of the crew is our distinguished colleague, Jake Garn, it becomes a noteworthy event.

The original mission of 51-D was not to be all that dramatic, if one can downplay any of the tremendous feats that have become a routine part of the shuttle. This flight, more than any others, however, showed that the shuttle and its human element give NASA and the entire space community a flexibility unequalled by any other system.

The effort to reactivate the Leasat is an example of ingenuity, courage, and a tremendous ability to respond to adverse circumstances. I am not concerned that the reactivation was unsuccessful, and understand that a rescue effort may be undertaken on a future flight. The overriding point is that an alternate plan could be devised and implemented while the shuttle was in orbit. With any other transportation mode, no rescue or mission modification would be possible, and the satellite would have been a complete loss as soon as the motor failed to fire.

The obituraries that have been written for the shuttle are, in my view, premature, as this and all of the missions have shown. With each success, I think that we tend to lose sight of the fact that the shuttle is one of the most complex transportation systems ever developed. In my opinion, the shuttle has more than proved itsef, and I look forward to the report we will hear today, as well as the plans for future flights.

Senator GORTON. Colonel Bobko, we would be delighted to have whatever comments you would like to make and the comments of any of your crew before you show us the films on the flight activities.

## STATEMENTS OF COL. KAROL J. BOBKO, COMMANDER, SPACE SHUTTLE MISSION 51-D; CDR. DONALD E. WILLIAMS, PILOT; DR. M. RHEA SEDDON; CAPT. DAVID GRIGGS; AND DR. JEFFREY A. HOFFMAN, MISSION SPECIALISTS; AND CHARLES D. WALKER; AND HON. JAKE GARN, U.S. SENATOR FROM UTAH, PAYLOAD SPECIALISTS

Colonel BOBKO. Mr. Chairman, we certainly are honored to be here. We would like to share with you some of our excitement about the space program.

As you may know, this mission started out to be a rather routine space flight, if you can consider space flight at this stage still to be routine. We were supposed to launch two satellites, do electrophoresis operations in space, do medical research in space, and do a number of other lesser experiments.

As it turns out, we were called upon to fabricate a fly swatter as we called it, do an unplanned EVA, an unplanned rendezvous, and then the swat operations. I believe that this flight has shown the maturity of the NASA program and the adaptability and capability of that team and of our shuttle crews and of the ground people who support us.

And I think it fair as well for what we look towards in the future, where we will be demanding more of our shuttle crews in the shuttle missions, and of course we will be looking to the day of a space station where man's adaptability and capability to exploit the opportunities that are presented to him will be used even more.

We think that NASA has shown itself at its finest here, even though unfortunately the switch operation did not work. It is interesting to note that even while we were in space, NASA was planning to revisit that satellite with the information that we had used and right now the date is set for late August, when they again plan to rerendezvous with the satellite and activate it, carry up to three satellites, and hopefully launch four.

Senator GORTON. Do any of the others of the crew wish to make a statement?

Senator GARN. Mr. Chairman, thank you for this opportunity. I will not take long, because the movie is far more interesting than anything I have to say. For the last several weeks I have had the opportunity to praise this crew, but not in a public record being taken down and I want it part of this Committee record of the incredible opportunity that I had to fly with these great people.

We will talk about the space flight itself, but to train with them for three months dozens and dozens of simulations of various types, spend seven days in orbit in a weightless condition, in a not very big amount of space, you get to know people very well.

So, not only do I have great respect for them personally and as human beings, but I am kind of an expert in watching crews after 30 years. I participated with a lot of them. But never I have I seen more competence or professionalism than in these six colleagues of mine.

I saw them through the training over and over and over again. I saw it on launch. But where I really got to see it is when we were doing the things Bo mentioned that were not planned, to show you the real competence of them.

Everything in the space flight should go through on a crew action plan, a flight data file, on a very close time line. We got up at 3:44 a.m. for our launch, not 3:45, not 3:40, 3:44. And you go through the entire sequence of events on our planned five-day mission with that kind of precision, yet suddenly when that satellite would not function properly, we had no crew action plan.

We had no flight data file. We had no instructions or check lists. It came up over a teleprinter, dozens and dozens of feet of teleprinter materials, and to see the crew respond to an entirely different situation for which they had not been specifically trained, to see Don and Bo rendezvous with the satellite at close to 18,000 miles an hour, and as an old pilot who has done a lot of formation flying, it is a heck of a lot more difficult to rendezvous in those conditions and at those kinds of speeds.

Bo brought that spacecraft and satellite together. We did an orbit about 35 feet around it, a 360 to take a look at it, brought it down right over the cargo bay, stabilized there at one point for about 5 minutes. He touched nothing. He had those relative speeds so wired. And just as fine a job as I have ever seen done in any type of aircraft.

He did make a comment at the beginning of the rendezvous, and I certainly knew he was kidding when he said, I hope I remember how to do this. Well, believe me, I can certify he remembered how to do that. And Don did, too, as they were a team in performing that rendezvous.

Jeff and Dave did not anticipate going outside. They had trained for a long number of months in a WETF water facility to do different tasks, but they certainly had never been told they were going out to attach cross sticks and fly swatters, and it was just amazing to sit there or stand there or float there, I guess—you cannot sit or stand, but float there on the flight deck and watch them perform outside for over three hours.

And Dr. Seddon, I am sure, in her surgical residency was never told that she would be manufacturing fly swatters in space out of flight data file material from our checklist, plastic, gray and silver tape, a giant needle with string for thread, and a swizzle stick, but the one she made on instructions from Houston, when we got back and saw the one they made, hers was a lot better. It really was. It was better than the one they made on the ground.

To operate that arm requires great skill, and she did it beautifully, as you will see in the film.

Charlie Walker's, only complaint was, he had to sit too close to me. He was the one who had to sit on the middeck next to me. But a great engineer and scientist from McDonnell Douglas who I think a couple or three years or even maybe sooner you will find that there will be some great medical benefits as a result of what he has been doing for his company in space.

Well, I am taking longer than I intended to, but I wanted to spread upon the record of this Committee what a marvelous group of Americans these six are. They sit on 4.2 million pounds of fuel. As Rhea described the other day, it is rather a controlled explosion as you launch into space.

They are not paid very much for what they do, for the long hours and the risks that they take. They are a great credit to their country, and as much as I remember the space flight, even more important is my relationship with these great people.

Thank you, Mr. Chairman.

Senator GORTON. Thank you very much.

Colonel?

Colonel BOBKO. We can start the film, and we would like to narrate it.

[Film shown.]

Mr. Chairman, we trained for some time as a crew. There were a couple of changes, and so this was the fourth emblem that we had for our flight, and of course the one that we finally flew.

The crew is coming out from the crew quarters, myself and Don Williams, Rhea Seddon, Jeff Hoffman, Charlie Walker, Dave Briggs, and Senator Garn.

We go from there out to the vehicle, and did the launch preparations, and here is the start. These are really just hydrogen burners. They burn off excess hydrogen. And quickly you will see the engines start. They start one at a time, and they start 6 seconds before we actually raise off of the launch tower so that they are in a stable condition when we take off.

They only generate about 1 million pounds of thrust, so we can still be strapped to the launch tower while they are burning. When the solid rocket motors go, the launch hold down bolts are exploded, and we take off. When the solid rocket motors go, you know that something has really happened. You know that you are going to move away quickly. You hope it is in the right direction.

A few seconds above the pad, the vehicle starts to roll so that it is pointed in the proper direction for the orbit that we are going to enter, and of course at this time there is quite a bit of vibration and sound as we are traveling through the atmosphere with those huge rocket motors beneath us.

We get speed very quickly. At 19,000 feet we are already doing Mach I; 35,000 to 40,000 feet, we are at the highest dynamic pressure, the highest wind load on the shuttle, and of course above that we start to

get above the atmosphere and so the wind load decreases. The solid rocket motors only burn for two minutes, and then we remain on the main engines for the remainder of the eight-and-a-half-minute flight into orbit.

Once we get into orbit, of course, that is when the orbital operations begin.

Dr. HOFFMAN. The main part of our orbital operations as we originally anticipated was the launch of two telecommunications satellites. This is the first one for the Canadian Telesat organization. Communications satellites are the bread and butter of the shuttle program, and of course contribute billions of dollars every year to our economy.

This satellite worked just fine. That rocket motor you see at the bottom of it fired 45 minutes after we launched it and took it from the shuttle's orbit of 200 miles up to a geosynchronous orbit of 22,000 miles. After we launch a satellite, we also have to fire the shuttle's engines to get the shuttle away from the satellite before the satellite's motor fires.

The next day, we launched the second of our two satellites, the Syncom satellite built by Hughes Aircraft. That white stick you see in the middle of it is an antenna which we expected to see pop up about 80 seconds after we launched it. That would have been an indication that the satellite sequencer was working. We did not observe that, so we watched very closely to see if the satellite started to spin up, which is the next thing that should have happened.

Its spin rate, however, did not increase. We knew that something was very seriously wrong with the satellite. We did not know what, although people on the groundimmediately started thinking of what the problem might be and what might be possible to do about it.

We had to fire our shuttle engines to get away from the satellite because there was still a possibility that the satellite's engines might fire shortly thereafter. When we fired the shuttle engines, you will see what happens inside the shuttle, because the shuttle, of course, moves forward, and so everything inside starts moving backwards.

Here the engines fire, and you see the rather comical results inside.

Senator GARN. As you can see, Mr. Chairman, as you were calling it, Barfing Jake Garn. I am especially suited to this particular experiment because of my slightly receding hairline. This is an electro-encephalogram measuring brain waves, and I am sure my colleagues will be glad to know that I do have some.

Dr. SEDDON. This is another one of our medical experiments on board, the echocardiograph experiment. The transducer that I have in my hand emits soundwaves. The soundwaves are reflected off internal organs received back at the transducer, and a two-dimensional picture of the heart in this case is generated. We are looking at, of course, changes in the size of the heart and the volume of the heart that are seen in weightlessness.

This is an off the shelf item. For the first time we are able to see inside the human body in zero gravity. That is my heart beating with the mitral valve on the left side of the heart. We were able to do this experiment on four different people on the flight, and we hope we brought back some good information about some things that happen to the human body while in weightlessness.

Mr. WALKER. McDonnell Douglas and Johnson and Johnson, in cooperation with NASA, are proving that medical improvements in space can be made to pharmaceutical production. Here I am working at the electrophoresis apparatus, making adjustments, and in this scene testing the quality of the separated pharmaceutial material.

It proved to be excellent. We were 100 percent successful.The material has been turned over to Johnson and Johnson for their test program for the Food and Drug Administration.

Dr. HOFFMAN. We were the first shuttle crew to take toys into space. We worked on a project together with the Children's Television Workshop. The Houston Museum of Science will be distributing a lot of the footage that we took to schools all over the country.

We hope that seeing scenes like this will illustrate to children, as nothing else can, the difference between the environment of space and the environment here on the ground, and perhaps stimulate some minds of young people to work a little harder in their science and math courses.

Here you see me using a little magnetic Wheelo which when I am holding it is very similar to the way it works on earth. When you let go of it, it behaves, of course, completely differently.

Captain GRIGGS. Entering from the right stage, the yoyo was expected to not work at all from our preflight analysis. However, in space, I was able to notonly work the yoyo excellently, I was able to do it slow enough that I could understand the dynamics between the mass of the yoyo, the string, and the wrist, and actually make real time corrections to the tricks.

Mr. WILLIAMS. As you have perhaps noticed so far, none of us had any fun doing this. When they said we had to do serious scientific experiments, we promised to try not to smile when a camera was on, or at least while it was being downlinked to the ground.

Jacks was a somewhat dangerous experiment in that if the ball ever hit them, they would spread all over the cabin, so we had to be somewhat careful in collecting them, but I am happy to report to you today that before the flight was over Dr. Seddon really did get her twelvsies.

As you can see, there were some serious aeronautics done on board. Jake's paper airplane is unstable when floating around due to the air currents on board the orbiter caused by the fan and circulation system. With a verylight toss, though, it sailed extremely smoothly, right across the cabin.

Action and reaction perhaps is illustrated by a paddle ball, once again a rather normal reaction until it is turned loose. Now, shooting marbles in space was a little bit different in that you can see Dr. Hoffman

making sure that he keeps track of his shooter and not letting it get away, and also the circle that you might draw in the dirt or on the sidewalk when I used to play marbles is a somewhat more difficult thing to do in space.

I understand some of this is done around Senator Garn's town. It is not as easy as it looks. However, with a little practice, we did manage to juggle in space. The little car depends upon centrifugal force to stay within its plastic track. On the earth, of course, as it slows down, it falls out of the track, and in space, with a little help from Dr. Hoffman, it falls out of the track.

Our unofficial mascot, nicknamed Rat Stuff, really flipped out over this flight.

Dr. SEDDON. The next morning we found a teleprinter message that said Instructions on Building Fly Swatters. Of course, NASA's responsibility for the Syncom satellite ended once it deployed it from the cargo bay, but since it was having problems, we had enough fuel, and we had had sufficient training that NASA felt it was worth our while to go back and try to rendezvous on the satellite and try to activate the one thing on the outside of the satellite that we could get to, an on-off switch.

We were able to manufacture what we later called a fly swatter and a lacrosse stick from some metal tubing, plastic book covers, needle and thread, and a lot of gray tape, in attempt to snag the switch that protruded from the outside of the satellite.

Captain GRIGGS. Here we are on day 5. Jeff and I are getting ready for our space walk, our extravehicular activity. Jeff is putting on the lower torso assembly at this point. The white garment around his body is the liquid cooling garment, and we circulate cold water through that garment which provides a restricted area for the plastic tubes that the water circulates through.

Jeff has got a fly swatter and lacrosse stick. We want to make sure that we get those into the air lock. Our air lock is directly in front of Jeff right now. And we will be popping into it in a second. Here we go.

Bo is helping me get into the hard upper torso assembly, hooking up the communications cable. You can see the air lock is very small. I am hanging on the right. Jeff is pumping up into the hard upper torso at this time.

The suit is made up of five pieces, the lower torso assembly, which is the pants, the hard upper torso, which Jeff just popped into, the two gloves, and then the helmet. That comprises the outer structure of the suit.

Here we are just before we take the air lock down to zero pressure and getting ready to go out into the vacuum of space, making some last minute checks on the gloves to make sure that they fit properly.

And here we are exiting out into space, coming out of the air lock, out of the outer hatch. The area just to the right of us, the little square area just to the right is where our tools are kept, the tools that were used for the several different tasks that we may have had to do in space, and in particular this task itself.

Rhea has positioned the arm, which is protruding down over the upper right screen. She has positioned the manipulating system arm over the right launcher arm. Jeff has taken a position on the outboard side, and I have taken a position on the inboard side.

If you look closely in the background you can see the coast of Mexico drifting by. We were out there for just about 3 hours and 8 minutes during the total EVA. The task, of course, was to put the two devices that Rhea and Jake and the rest of the crew had put together the previous day, onto the end effector: hook them on with a come along device, which you are familiar with, and get them attached tightly to the end effector so that Rhea on the next day could hopefully swat the switch that we suspected had failed on the satellite.

Here is a clear shot of the back pack, and also a very interesting shot of the earth in the background with the very, very thin atmosphere that surrounds the earth, and the blackness of space. Once you get out in the atmosphere, with nothing to defract the light, space is absolutely black.

I started to speak about the back packs. In those back packs we carry our life support system, which consists of our oxygen supply, the coolant system for the water which we circulate around our body, and also our communications capabilities.

The two cylindrical objects in the foreground are the getaway special cans which I think most people are familiar with now. They are a very, very inexpensive way for industry, science, school projects, and things of that nature to get into space.

Here we are. We have finished the EVA, and now we are going to do a bow to the camera. Jeff does a bow. His feet come up instead of his body coming down. And we are about ready to go back into the air lock, repressurize, and turn it over to Bo and Don for the rendezvous.

Mr. WILLIAMS. Once the space walkers had finished their task, it was my responsibility along with Bo's to try to rerendezvous with the satellite that we had been maintaining a distance of some 40 miles away from.

A rendezvous in space is not quite the same as flying formation or joining up in an aircraft, both of which we had some experience with before. You do a series of rocket engine burns very carefully timed in order to position the orbiter in the proper relative position of the orbiting spacecraft, with the target, which in this case was the Syncom satellite we had deployed some three days earlier.

The flying, when in close formation with the spacecraft and other orbiting spacecraft, is done from the back of the ship rather from the front, as you might fly an airplane. Bo brought the 200,000-pound orbiter within about 20 to 25 feet of its orbiting spacecraft as we were both traveling around the earth at about five miles per second, beautifully nulling out the relative velocities between the two spacecraft in preparation for an attempt to trip the switch lever on the orbiting Syncom spacecraft.

In the rectangle in the lower righthand corner, you perhaps can see the switch lever protruding out of the side of the spacecraft, and that is what Rhea is going to try to snag with the manipulator arm device.

Dr. SEDDON. The remote manipulator arm is also worked from the aft part of the flight deck looking out the large windows that we have overhead. Here is what the fly swatter and lacrosse stick look like up close. We are trying again to snag the switch and to hopefully tear through the wire or the plastic so that we do not damage the arm.

The first try got the wire of the lacrosse stick. As the switch comes around again, we are able to catch it on one of the rungs of the fly swatter. On our last attempt they asked us to try to hit the switch with the base of the fly swatter. We were able to do that, at least three good hits on that switch.

The satellite did not appear to activate. However, we were told just in case that booster motor fired we should separate from the satellite at this point in time, but before we had even landed, as Bo mentioned, members of our office and people from Hughes were already planning a later salvage mission on the satellite.

Mr. WILLIAMS. That salvage attempt is now scheduled for the end of August this summer.

Unfortunately, all good things must come to an end, including the space flight. We all wanted to stay, but they would not let us. So, we did the orbit burn, which occurs to the west of the continent of Australia, reentering the earth's atmosphere about halfway between the Hawaiian Islands and the western coast of the United States and Mexico at 400,000 feet at about Mach 25.

From that point, the orbiter slows down to a point where we can land it, somewhat like an airplane on a runway down in Florida. As we roll onto final here for the final portion of the approach, Bo is flying the airplane, and I will let him describe the landing.

Colonel BOBKO. We had waved off one time. We had to go around the earth one extra time, because the weather was not suitable there in Florida for a landing the first attempt, but you can see that when we finally do land it was a beautiful day.

There was a bit of a cross wind, but we could see the runway clearly. Here is our final approach into the runway. We are coming here over the Banana River, and if you look very closely, you can see the gear come down from the bottom of the shuttle.

The runway approaches. We come over the runway about 15 feet, and finally make the landing, and then a few seconds later put the nose down. The runway is 3 miles long, but you must remember that as Don said, we started this approach west of Australia, and so that does not give you very much margin.

Stopping, however, was no problem. We stopped with over half a mile of runway remaining before us.

Everyone felt good about the mission. We had used all of the training that we had been trained for in the last year and a half.

We had the opportunity to do things that we never had expected to do. They were all challenging. They were all exciting. From our point of view, our parts were successful. However, what we did was not successful in activating the satellite.

If you watch the faces of the crew here, you can see we were all enthusiastic about our space flight. Most of us are scheduled for another space flight, and I understand the few who are not are lobbying for a second one.

These films showed much of the operational activity that took place on board the shuttle, and of course you had very little chance to look at the earth, and we think that it is important to appreciate some of the views that we can see of the earth, and some of the significance of them.

So, we have collected a few views here that we took during our 7 days in orbit, and I will ask Dave Griggs and Jeff Hoffman to narrate those for you.

Dr. HOFFMAN. This is a view of our home town, Houston, the Gulf of Mexico at the bottom. You can actually see the Johnson Space Center in this picture. In fact, it is remarkable what you can see, the variety of the scale of the earth and of human habitation which is available to people up in space.

This slide just cannot give you the horizon to horizon sweep which we can see out the windows. You can see almost a whole continent at a time, and yet the detail that is available is also amazing. When you look out on a scene like this, and especially if you use a pair of binoculars that we carry with us, you can actually make out individual buildings. So, from buildings to continents, you can really see it all from space.

Senator GORTON. As you pass, what percentage, what share of the world is generally cloud-covered? How much of the ground are you seeing and how much is cloud?

Dr. HOFFMAN. That is widely variable according to what season it is and where we are passing over. Generally the tropical regions tend to be cloud-covered most of the time. We were very fortunate on our flight. We got some of the first good pictures taken from space of the Congo region, which had really hardly been photographed before because of the clouds.

And similarly the Amazon region turned out, especially on the last day or two of our flight, to be almost free of clouds, and we got some good pictures of that.

The deserts, of course, are almost always free of clouds. And then with the oceans it is variable, depending on the weather patterns.

I should say that we tried to take these pictures and do these observations not just as tourists. We spent a lot of time before the flight training by talking to oceanographers, meteorologists, and geologists.

They showed us what previous crews had photographed, talked to us about some of the outstanding problems, and told us what pictures we could take that would be useful to them scientifically. We plan this out beforehand. We have a list of objectives.

And we are very pleased that the pictures we take are not only beautiful but they also are useful scientifically.

The scope which you can see from space is apparent from this picture of the tropical storm Margo off the northwest coast of Australia.

And of course we can see tropical storms using unmanned meteorological satellites: but take a look in the eye of that storm, the remarkable detail which you can see. This is very useful to meteorologists in studying the dynamics in both the genesis and the

eventual waning of storms. We can really complement the pictures taken from the earth of unmanned satellites. We can respond quickly, and we can also get detail which is just unavailable to other satellites.

Captain GRIGGS. This is off the west coast of southern Africa, just north of the Cape of Good Hope. The green matter in the water is of interest.

That is known as the Benguela current. The Benguela current originates out of Antarctica. It spins off that shelf, remains underneath the surface of the water, and actually migrates northward undisturbed by the waters around it.

It eventually rises to the surface on the west coast here of Africa en masse, once again without mixing with the local waters. It is a very cold current. It is very nutrient-rich, and the green matter there is the phytoplankton that is associated with that current.

The coast here, as I mentioned, is the west coast of Africa. It is an extremely dry region of Africa. The local rainfall in this area is measured in centuries, and it averages about 3 inches per century.

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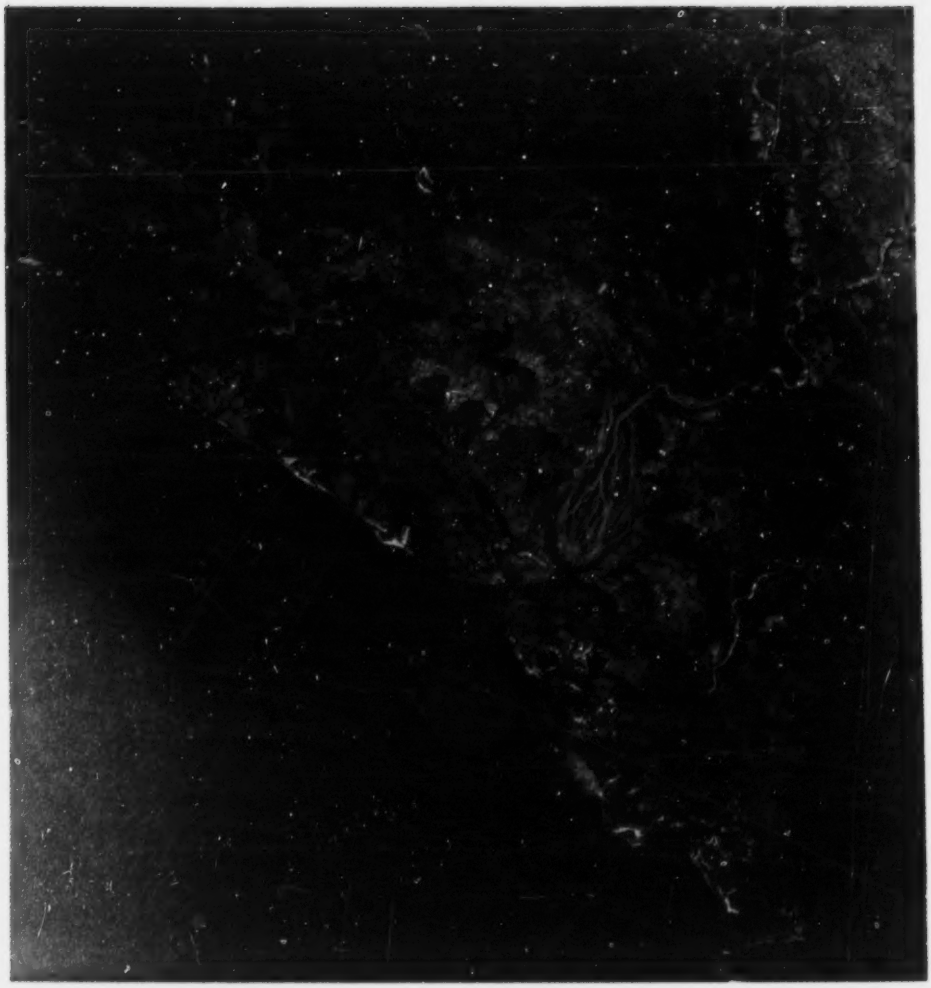
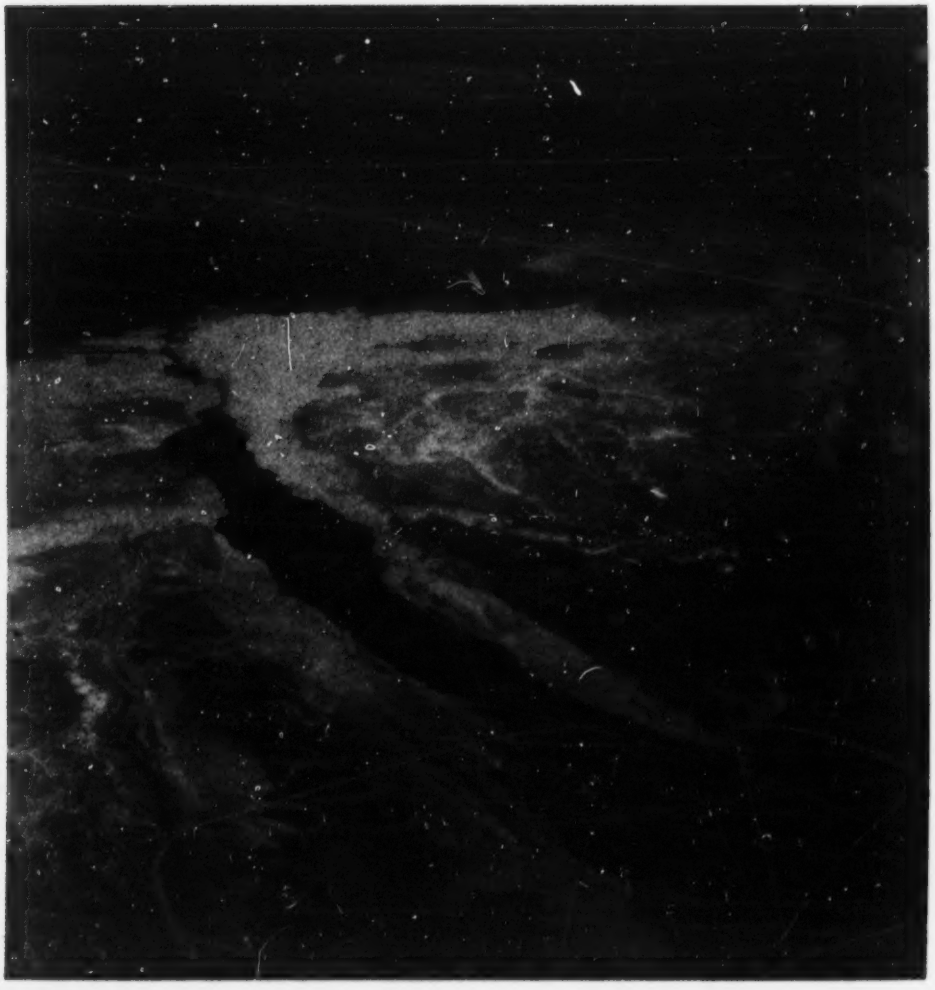


This is the entrance into the Red Sea. The land mass to the north is the land of Yemen. Just to the south of it is Ethiopia. That land mass is not apparent in the picture. It is a very narrow entryway into the Red Sea.

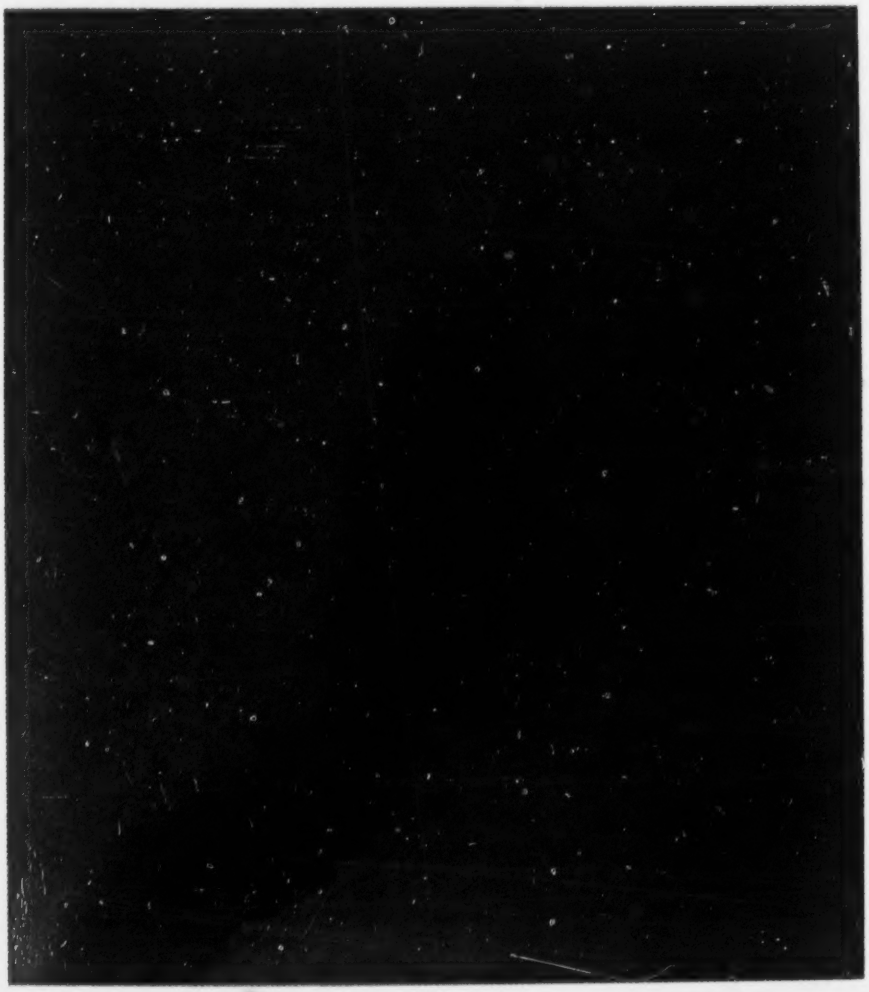


The point of interest here is the wave patterns that you can see in the wakes of the islands. These wave patterns, of course, are supported by visual light that we can see from our spacecraft. It enables us to go back to oceanographers and provide this information of different ocean phenomena that are visible with the human eye.

This is only one example. We also have examples of large spirals and eddies out in the mid-oceans which demonstrate a tremendous amount of energy that exists in the ocean that we are really not aware of.

Dr. HOFFMAN. And we ought to mention that these spiral eddies were completely unknown before they were photographed by the second flight of the shuttle. Oceanographers were quite astounded by it, and very enthusiastic, and have studied these things quite extensively since, because a tremendous amount of energy in the ocean is involved in them. And they are also of great interest when you are looking at the propagation of sonar waves under water.

Well, we see, unfortunately, from space not everything is beautiful. We see a fair number of examples of how the earth is ravaged by both natural catastrophes and also by the effects of humanity. This is one example of the former. This is Lake Chad.



We have been photographing this from manned spacecraft in the last 15 years, and back at that time this entire reddish region was filled with water, and now, because of the extensive Sahalian drought in Africa and all of the human suffering that we know is going along with this, the lake has shrunk down to this very small portion which you can see here.

Of course, pictures like this do not tell us how to end these problems or alleviate them, but hopefully we will learn some things about the climate of the earth, and at by being able to perceive worldwide trends, perhaps can prepare for climatic changes, and so perhaps alleviate some of the human suffering which goes along with them.

This is an example of manmade ecological disaster on the island of Madagascar, which is a closed ecosystem, and again we have been studying this for years. Down in the lower left you can see some very rich mahogany forests. Of course, the price of hard wood is very high. The economy is rather poor.

And they are clear cutting these forests. You see large bare regions here. They are not being replanted. The iron-rich soil, which is reddish in color, is being washed down, and the river is taking it out to the sea here. This whole bay as little as a few decades ago used to be a magnificent deep water port.

The French used it for a few centuries. It is now completely filled in and silted up and essentially useless because of all of the erosion that has taken place.

Captain GRIGGS. This is a marvelous picture of the Mideast. The scope of what you can see from space is not done justice by this slide. Of course, you are restricted by the lens size itself, but what I would like to describe here is what is available to see. This is Egypt off on the

left, the Red Sea going up through the Gulf of Suez, on up into the Suez Canal, the Mediterranean, backhere, Port Said.

Off in the distance you can see the highlands of Turkey. Over here is the Gulf of Aqaba going up to this large riff, on up into the Dead Sea, which is very nearly 350 meters below the surface of the ocean, the Sinai Peninsula, Saudi Arabia, on up into Israel, Lebanon, Syria, Jordan, up through this area.

Remarkable, the scope of what you can see from space. Here we are over in the Pacific. This is Queensland off the northeast coast of Australia, and this is the Great Barrier Reef, which most of us are familiar with. This stretch along here is about 60 kilometers. The reef itself is about 2,000 kilometers long, and it is a live coral reef formed by the secretion of calcium carbonite from the coral.

Dr. HOFFMAN. What better way to end a day than with a sunset? Or perhaps this was a sunrise. Of course, we see 16 of each in the course of a 24-hour period since we are moving around the earth at 18,000 miles an hour.

This is a beautiful example of the mixture of technology and aesthetics, because sunrises and sunsets, in addition to being among the most beautiful phenomena that we observe from orbit, are also very interesting to atmospheric scientists.

They requested that we photograph as many of them as we could, because they look at the banding of the atmosphere up here, and in fact at times we could see up to 20 separate layers, and this gives information about the physical structure of the atmosphere which really is not obtainable in any other way.

I will leave off now the scientific description, just to remind you once again of the beauty of everything that we see in space. I apologize that the technology of color slides really just does not do justice to the full sweep of the color.

Nevertheless, despite the inadequacies of the slides and the limitation of the time we have to speak to you, we hope that we have been able to share with you some of both the beauties that we were able to see and also some of the useful work which we were able to accomplish.

Colonel Bobko. May we have the lights again, please?

Mr. Chairman, we hope you have enjoyed some of the film and slides that we were able to take on our flight. We are honored to come here, as I said before, because I feel that space is the challenge of our time, and if our country is going to remain vibrant, productive, and safe, we must participate in this activity.

I hope that us taking Senator Garn along will be beneficial. I hope that he will serve as a bit of yeast in this body to keep it rising to this challenge over the years to come.

Senator GORTON. That is a new description of Senator Garn. But we will take it under advisement.

Colonel BOBKO. We would certainly be happy to answer any questions you might have.

Senator GORTON. Colonel, I would like you to tell us a little bit, and delegate as much of this as you want, about Leasat, the nature of the problem and what you have learned and how that knowledge will be utilized in the attempted rescue mission in August.

Colonel BOBKO.I think Dr. Seddon probably knows more about the attempted rescue than I do.

Dr. SEDDON. Unfortunately, this satellite was the one that I had responsibility to deploy, and the deploying of the satellite went completely normally. We had no malfunctions in the launch sequence and the deployment from the shuttle. We did not realize there was going to be any problem until about 80 seconds later, when we expected things to happen and they did not.

The people on the ground immediately began questioning what could possibly have gone wrong. The only single point failure in this whole system was that separation switch on the outside that was supposed to deploy as the satellite came out of the cargo bay.

They thought that the only single thing that might have failed was that switch may have hung up on something and not come out against its full throw. It was to activate their sequencer. As it looked, of course, we came up and verified that the switch was indeed out, hit it several times to make sure it was all the way across to hit its microswitch on the other side.

Senator GORTON. That is what you did with the fly swatter?

Dr. SEDDON. That is what we did with the fly swatter, and I think that was a bit of useful information to them. If we had not gone back, their bet would still have been that it was that switch that had malfunctioned.

As they looked further into if that was not the problem, what could have been, there was a relay in the line between their power system and the computer, the sequencer that is supposed to come on. There are several switches in that line that would have had to have failed in the open position.

They believe that is what the problem was, some sort of vibration or movement caused some switches in line to open up. There are some test ports that come from the inside of the satellite electronics to the outside that are used as test ports on the ground that they believe they can hook wires across, put on a sequencing box to bypass the failed switches.

We have a crew later this year, in August, I believe, who plan to go up, rendezvous with that satellite, hook onto those test ports a box so that ground command can get into the satellite. They plan to attach this, spin the satellite back up, and hopefully send it on its way by ground command.

Senator GORTON. Do you have any kind of estimate now, or does NASA have any kind of estimate as to the prospects for success in that mission? Is it 50–50, less, more?

Dr. SEDDON. I sure wish I could give you a number on that.

Dr. HOFFMAN. You know, the big problem when you are dealing with something like this is that the satellite is up there and we are down here, and how can you be 100 percent sure of what the problem is?

What they are planning is to install these little jumper wires on the satellite which will basically bypass this entire sequencer assembly. Internally, it will make the satellite think that it is back on the ground and is therefore amenable to commands that the ground will send it, only they will be coming from radio instead of from the ground test equipment.

Now, there are numerous other questions involved here. The satellite will have been up there for a long time. Its batteries probably will still be functional. They should still be charging from the solar cells. That is something that the crew will have to check out. There is no way that they can test that until they get up there. There is a lot of rocket propellant on board. That probably will have frozen and thawed out several times. There may possibly be ruptures in some of the lines. People are doing analyses here, but there is no way to check it until you go up.

Senator GORTON. In any event, it will not be a command from the shuttle which is used to attempt to activate the satellite. You will be establishing what amounts to a communications facility between the earth and the satellite, and the commands will come from Houston, I take it.

Captain GRIGGS. Yes, sir, that is correct. I would like to also point out that this a reimbursable effort, that the manufacturer of the satellite does intend to pay NASA for this effort to rescue the satellite.

Dr. SEDDON. So apparently they feel that the chance of success is great, and NASA feels in looking at all of their plans that it is a safe and doable operation, so they are willing to do it.

Senator GARN. Mr. Chairman, I would make one more comment, too, from a budgetary standpoint, that that is still Hughes Aircraft's satellite. The Navy was not going to start paying for it until it was in space and operating it. It is in space, not in the proper position, not operating, so it has not cost the U.S. Navy anything yet, and will not unless it is functional.

Senator GORTON. What is the charge for the rescue attempt?

Senator GARN. I do not know.

Captain GRIGGS. I am not positive, but I believe the number is right around $10 million. That is what I have heard, but not officially.

Senator GORTON. For an $85 million satellite?

Mr. WILLIAMS. That is what it is insured for.

Dr. HOFFMAN. And remember that that is one of the great things about the way the shuttle operates. The shuttle is going to be up in space anyway, so we are not having to put together an entirely new mission to go up there and rescue it.

That is why we can do these things on the shuttle relatively economically. We are really starting to see how we are able to make use of the shuttle in a rather short time scale to do things which just would have been unheard of before.

The sky is literally littered with satellites that have failed over the last 20 years for a variety of reasons. I think people are not really aware of that, probably because when the satellite was launched and did not work, it really did not hit the news like this does, and it is really only now that the shuttle has come around that we have the hope of doing anything about these.

Senator HOLLINGS. On that particular point, if you do not mind, Mr. Chairman, do you have radar or something of that kind to make sure that you do not run into one of those satellites? I always wondered, with all the objects floating in space, how you avoid them.

Colonel BOBKO. The North American Defense Command keeps track of objects in space, and they will notify NASA if the trajectories are going to come within some distance. I do not remember what it is exactly. But if they get close, they will tell us.

Senator GORTON. On the landing gear problems, would you talk a little about them? Did they indicate any kind of design deficiency? Are they relatively easily correctable? What do you plan in that connection?

Colonel BOBKO. When we landed there was a wind from the right and we drifted to the left. I used the rudder to bring it back toward the center line and then used the brakes to keep it tracking along the center line. Since the wind was from the right, the right brake got more use than the left one did and it got to its maximum energy capability, heated up, failed, seized that wheel, and then that stopped the tire from turning, of course.

The shuttle runway on the Cape is rather rough because they didn't want you to skid in case it got wet in a summer thundershower, and so that ground off the tire, which caused it to blow out just a few seconds before we came to a complete stop.

There have been tire, wheel, and brake problems with the shuttle of one sort or another over the course of the program, and this realization that we were not able to handle the wind that we had with the shuttle weight we had has resulted in the shuttle being landed again at Edwards while they look at the problem and re-engineer or decide what they have to do to make sure that the brakes and tires will work satisfactorily to again attempt KSC landings.

Senator GORTON. You anticipated my next question. Is it likely that we are going to resort to using Edwards as a permanent landing facility, or will Kennedy be sufficient, with a few corrections?

Colonel BOBKO. That's being studied now, sir. We will have to wait until the results of those studies come out. Certainly everyone is anxious to get the landing at Kennedy back into the program since it saves days on the turn-around. But we are unwilling to go back there while there are still questions about the capability of stopping on that runway.

Senator GARN. Can I just add, Mr. Chairman. When you said "permanent," no, it is not permanent. It is temporary until—and I would expect from what I have heard here at headquarters that we will have a redesign of the brake, and from what I have heard it is a brake problem. With the small amount of cross-wind that we had and the relatively small braking power that Bo used, that brake should not have failed under those conditions.

And I expect we will have a brake redesign, and as soon as that is accomplished we will be back at Kennedy.

Senator GORTON. Mr. Walker, how far do we have to go in the future before your electrophoresis manufacturing operations have reached the point at which we are doing something which is available commercially?

Mr. WALKER. Mr. Chairman, we are in the middle of our development program, developing the equipment and the process to purify pharmaceutical materials using the weightless environment of space. We have been very successful so far.

With this last flight, we have turned over purified material to our partner in the private sector in this endeavor, Johnson & Johnson. They have begun the extensive animal testing program which will phase into a clinical testing program using these materials brought back from space.

This program is required by the Food and Drug Administration to verify the safety and efficacy, verify the effectiveness of that material, before the Food and Drug Administration is able to say yes or no—we hope certainly yes, we can market this material.

We expect that the data sufficient for the FDA to make a decision should be available in 1988. So that by 1988 we hope to have verified, by perhaps two or three more flights with equipment on board the Space Shuttle, the equipment which will then produce the pharmaceutical materials starting in the 1988 time frame.

We would like to believe, and we do believe by the success we have had so far that in the 1988, that early in the 1989 time frame there should be available to clinical physicians material, this first pharmaceutical material that we have in mind, which would be a breakthrough material that is not currently available to physicians. It would be used to treat certain medical disorders, the identity of which we have retained as proprietary information at this point.

But again, it would be a breakthrough material that would be used to treat several million patients in this country alone.

Senator HOLLINGS. Mr. Chairman, that is what I was going to ask. I do not want to discuss any proprietary information, but what can you tell us about these pharmaceuticals? What kind of diseases would they beat?

Senator GARN. Senator Hollings, if I can interrupt you, I tried for 7 days in space and I can tell you to save your breath. Charlie would not tell, even when he was asleep, even when he was upside-down. You are not going to get that information out of him, so you might as well——

Senator HOLLINGS. Well, we ought to get him on the Intelligence Committee.

He is the first fellow I have met that can keep it quiet.

Senator GARN. As a matter of fact, I said that to Charlie yesterday, that we need a lot more of him in Washington because of the leaks in this town. If we had more Charlies, nothing would get to the Russians.

Mr. WALKER. Senator, with all due deference, in our agreement with NASA it has been——

Senator HOLLINGS. I am not trying to disturb that agreement. I am just wondering, for our benefit and the public's benefit, as a result of these experiments and the greater purity you can obtain in space, I take it that the drug then would work on certain ailments much more efficiently and/or effectively?

Mr. WALKER. Yes, it is a matter of both purity. We with this process have proven that we can obtain materials some four times purer than is possible on the ground. That characteristic of this process would allow fewer side effects from pharmaceutical materials processed thusly.

In addition, the economics of getting into space—it is very expensive to get into space, as we all know, and come back. The economics that allow us to take this material into space, improve it, purify it and bring it back again, are made possible by the fact that this process using the weightless environment of space works several hundreds of times more efficiently than it does here on the surface of the earth, thereby increasing the productivity of the process that much.

And I might say that again, we are talking about just one material at this point. Johnson & Johnson and McDonnell-Douglas are anxious to prove our process with one material, the risk that only one material affords us at this early point in the program. We have identified many others and we are talking to other pharmaceutical companies in addition to Johnson & Johnson, other research organizations. And we are in fact talking to other Government and other foreign pharmaceutical concerns.

So the interest is great and the applications are far-reaching. There are many other medical materials that show likely promise with this process.

Senator GORTON. Jake, I wonder if after this experience on your part you would share with us some of your thoughts at least on the American experience in space, what it means, what you see in the future, what you recommend to this subcommittee in partnership with your own subcommittee as far as our space future is concerned.

Senator HOLLINGS. Mr. Chairman, if I could join in that request. I heard that Senator Garn knocked them dead down at the National Space Club luncheon the other day. I know you do not want to hog the show bringing these important astronauts to the committee, but for the committee record, elaborate, if you please, as the chairman has asked, about not just the crew, but the program generally speaking.

Senator GARN. Well, I would be happy to and I will do it in much more detail. I am working on a report that will get into a lot more detail for both the benefit of my own subcommittee and of this committee and the Congress in general.

But I am sure you know, Mr. Chairman, of my long interest in the space program and my great support. When I say what I am going to, I am fully aware that the press will say: See, NASA bought him; now he is saying all of these nice things about the program. They have not listened for 10 years. It has only become noticeable, and maybe that is one of the really good parts about it. They will start to listen to what I have been saying for a decade.

I think the best illustration of what I can say to begin with is what Charlie just said. I am asked constantly a question about why do we waste money in space. My normal sort of flippant reply is, we have never wasted any money in space. I did not take a credit card or any money. There are no stores. No money has ever been spent in space. It has all been spent entirely—NASA's budget has been spent here on earth, solid rocket boosters in Utah and various places around the country.

So whatever benefit that Government spending is as far as recycling in the economy, it is spent here on earth and it is not wasted in space.

But I suppose my flight has enhanced my appreciation of the capabilities of space more than I could by sitting in hearings for the rest of my life, to view the capabilities of NASA and look at the communications, just look at communications alone, what we are doing today in commercial satellites or communications of voice or for navigation or entertainment, TV programs, any place in the world. That is just one aspect of it.

What we can do in terms—I suppose what Jeff was talking about really surprised me, because I sat in the earth observation briefings simply having no knowledge of how valuable photography of the earth was to so many different disciplines.

And each one of the disciplines that were briefing us, obviously theirs was the most important. You should have seen the eyes of the guys that wanted pictures of volcanoes, the volcanologists, and the oceanographers with the currents they have found and the movements in the ocean. They want 10,000 pictures of the ocean. And the geologists, the same kind of big eyes: You have to get these for us.

This is something that I was unaware of. Maybe you on the authorizing committee were. The value of photography alone in so many different disciplines is just amazing, the spinoffs and the new knowledge that has bee gained. As Jeff said, the oceanographers did not know that a lot of these currents existed at all until we got the photography from space.

It also can determine crop yields and bug infestations. You are able in some of the most far-away third world countries now, because of the use of satellites, to take pictures of people who are injured and sick and have doctors be able to look at that and make some diagnosis. And so in health areas spinoffs are just amazing.

And as you know, we are spending $7.5 billion a year, and that is a lot of money. But in terms of what we get back for it, it is not very much in relationship to many of the things that we spend in our budget it is a very tiny proportion of it when you consider that it is also not all for space.

NASA also does a great deal of work in aeronautical research. The super-critical wings that Boeing uses, Mr. Chairman, came out of NASA research to some extent. The more fuel efficient fan jet engines, crash safety programs that they are doing, testing in that area for both commercial as well as general aviation.

The list goes on and on and on. And so I think we vastly underfund the space program. I was a member of this committee when it was a separate, totally separate space committee, and Frank Moss, my senior colleague from Utah at the time, was the Chairman and Jim Fletcher was the Administrator of NASA. He sat at this table and we promised him 10 years ago that we would keep NASA whole for inflation.

Congress has not kept that commitment to NASA to keep them whole for inflation, and this year, as you know, we are freezing it. So I think the future is just beyond limit. And maybe I am taking too much time to explain it, but maybe this will illustrate the point I am trying to make and why I feel so much that we are eating our seed corn.

The results of freezing NASA's budget this year will not hurt NASA this year or next year. It is 5 or 10 years down the road probably when we will see the results or lack of results because of things that we did not provide for them to do now.

It really is the frontier of our future, not only for this country but I think the entire world and what we are able to do in space. And again I refer to what Charlie is talking about. If his company is able to do what he thinks they can, it will justify all the money we have ever spent in space, just that alone. The medical benefits, the lives saved, and the improvement in our lives on this earth, that one thing could justify even more. In fact, I do not know how you would even put a price tag on it.

So that is why I feel badly that we are talking about $7.5 billion a year. We spend more for chewing gum in this country. We spend $5 billion more for food stamps in this country, and I am certainly not saying we eliminate food stamps. But I think our priorities are rather misguided in this particular area.

So the story I want to illustrate about the future is, I spoke to my youngest son's kindergarten class a couple of weeks ago, just 6 year olds. And I felt impressed to tell them that some of those kindergartners would walk on the outer planets, maybe some of them live in a permanent moon colony, some of them may go beyond this solar system.

The kids thought that was great. The teacher's eyes were kind of rolling back in their heads, and I could just tell that they were thinking: Now, why is he making promises like that? That is ridiculous, to confuse these little kids and mislead them like that.

So I was primarily responding for the teachers and the principal and I said: Well, if you think that is really far out, to make that kind of a promise, that is not really much of a jump from where we are today with the technology we have, because what would you have thought if when I was 6 years old in my kindergarten class in Salt Lake City, Utah, in school and some bald-headed middle aged Senator had come in and given a speech and said, Jake Garn, some day you will orbit the earth 109 times at 18,000 miles an hour?

Now, when I was 6 it was 1938 and jet airplanes had not yet been invented. DC–4's were not in service. We were flying Boeing 247–D's and DC–3's. My father drove an automobile with wooden spoked wheels and television had not yet been invented, and certainly we had never heard of computers which we could carry around in our pockets that had eight digit functions and square roots.

Look at that leap from 6 years old to my age, 52, in 46 years. Look at the leap from my father being 10 years old when the Wright Brothers flew and watching men walk on the moon in the form of Neil Armstrong.

The future is absolutely incredible, and I suppose that, in a very general sense, that is the thing that I have been most impressed with in the space flight. It is limitless, gentlemen. It is absolutely limitless, unless we politically limit the future of this earth because we are not willing to have a vision of that future and what can take place.

We should be able to do that easily. Back in the forties and fifties, that took some men of great vision. It took great courage by President Kennedy to announce that we would put men on the Moon by the end of a decade. He was really sticking his neck out with our technology then. But we have so much background in the program, so much knowledge of what our scientific community can do.

And yet we have been cutting back in this area. That is short-changing the future, not the present. And Slade, you and Fritz know, as well as I do, now the problems of our budget. I recognize that. You know how I vote in this body in attempting to reduce that deficit.

But when we establish priorities, I think we have to look beyond the immediate problem and look to the future and see what kind of a legacy we are leaving future colleagues after we are gone from this body.

So I can be accused of whatever the press wants to accuse me of, of being bought by NASA or whatever. But nevertheless, I am going to continue to tell this story because I think it is such a fantastic and promising future. It is a future for the third world countries, for increasing the standard of living of all of God's children who live on the face of this earth. And if we neglect it we are going to be very, very sorry.

Senator GORTON. Thank you very much.

Fritz.

Senator HOLLINGS. Thank you.

I will yield to Senator Gore.

Senator GORE. Let me say that I for one really look forward to your full report. I know you have been working on it and I know it will be full of insights.

As a member of this authorizing committee, I agree with your outlook on the space program. It has always provided a bigger return on investment, if you want to put it on those terms, than anything else that the Federal Government has ever invested in, and we are very short-sighted if we do not recognize that.

I think you can be a very articulate and persuasive spokesman for that view and I look forward to your full report.

Mr. Chairman, I want to say one other thing in this hearing, and that is that we in Tennessee are awfully proud of Dr. Rhea Seddon. And in Murfreesboro, TE, it is just practically out of control, how proud they are of her and proud of her whole family, and she and her husband have the first astrotot. Is that an official title yet?

Dr. SEDDON. I am not sure it is terribly official. It is the one we like.

Senator GORE. Well, he is the only little boy in the world who can say, my mommy and daddy both fly in space.

Anyway, we were proud of her before she was in orbit and before she was in this program. She has had a very distinguished career, and I just wanted to say that for the record. I have said it on other occasions, but it is heartfelt.

And to all of this crew, I want to express my thanks for what we have learned and what we will continue to learn as a result of this mission.

Senator GARN. Mr. Chairman, I must tell a story about Tennessee, because we were down at the Cape and Congressman Bill Nelson was there talking to Dr. Seddon. And he mentioned that he was going to hold a hearing after our return flight, and I guess I did not fully understand the accent, because I thought he said he was going to hold a hearing in Murphy's Bar and that brought me to attention very quickly and I said: Rhea, you have got to be kidding; Congressman Nelson is coming down to hold a hearing in Murphy's Bar?

And she said no-- well, I still cannot say it.

Dr. SEDDON. It is Murfreesboro, but when you are from Tennessee it gets sort of shuffled around into "Murfsbro.'

Senator GARN. I was happy to hear we were not holding a Congressional hearing in a bar in Tennessee.

Senator GORE. Well, that hearing turned into a kind of mass celebration, with schools turned out and huge crowds, and it was really quite an event.

Dr. SEDDON. Much appreciated.

Senator GORE. Thank you.

Senator HOLLINGS. What about the shuttle tiles? You know, every time you turn on the TV you hear about problems with the shuttle tiles. What about that, Colonel?

Colonel BOBKO. Of course, there are 30,000 tiles on the shuttle.

Senator HOLLINGS. Is there a better design or something that we could be looking at?

Colonel BOBKO. We are finding out, unfortunately, there are always small problems with them. And of course, they are very critical of the tiles to ensure that they are all working properly or all have the capability of insulating the shuttle from the high heat load during the re-entry.

And we have had tiles that have been damaged. I guess the latest problem with them was that the waterproofing agent that they put on the surface of the tile had seeped down and caused the bonding agent to allow the tiles to become soft, become soft so that the tiles could come off of the skin of the shuttle.

So they of course wish to have the tiles waterproofed, because what can happen is that water can intrude into the tile, when you go into space part of it can evaporate out, and then if you come into the atmosphere and the tile becomes hot the water that remains can boil, causing some of the tile to chunk off.

That was the problem with the Challenger not too long ago. They have taken all of those tiles off, and of course that is a very labor-intensive operation. They have stopped waterproofing them with that agent. They are investigating other agents and they have put all those tiles back on the Challenger that had to be replaced and it is flying.

Senator HOLLINGS. Well, let me put it another way, What surface do the Soviets use on their platforms and other space vehicles?

Colonel BOBKO. Most of the Soyuz craft are not reusable, so they don't have tiles.

Senator HOLLINGS. It seems like we could make some improvement on the orbiter tiles.

Dr. HOFFMAN. I think we are making improvements. There are small improvements that are continually being made. I think the important thing to realize is what a phenomenal step in technology it was to develop these tiles. The United States in the development of the shuttle has gotten a 10, 15, 20-year lead on the rest of the world.

You know, when you ask how do the Soviets do this, they cannot. They do not have a Space Shuttle. They do not have anything this big that can re-enter the earth and be used over and over again. But they are working on one. And the Europeans have announced that they are working on a space shuttle. The Japanese are looking into the future.

I do not want my children to go into space using a Toyota shuttle. I want them to keep on flying American space ships. But it can happen and, you know, we have this tremendous lead in space technology which we have gotten through the shuttle program and which we hope to continue by building a space station, and I just hope that we can take advantage of that and continue to make the investment that is necessary to keep this lead.

We are going to continue to have small problems, that is the way technology works. I think the important thing is to realize how far we have come.

Senator HOLLINGS. Thank you.

Senator GORTON. Thank you all very much. We appreciate the message that you brought us.

The hearing is adjourned.

[Whereupon, at 11:22 a.m., the subcommittee was adjourned.]

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